

## **NESTEM-QRAS: A Tool for Estimating Probability of Failure**

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### **Abstract**

An interface between two NASA GRC specialty codes, NESTEM and QRAS has been developed. This interface enables users to estimate, in advance, the risk of failure of a component, a subsystem, and/or a system under given operating conditions. This capability would be able to provide a needed input for estimating the success rate for any mission.

NESTEM code, under development for the last 15 years at NASA Glenn Research Center, has the capability of estimating probability of failure of components under varying loading and environmental conditions. This code performs sensitivity analysis of all the input variables and provides their influence on the response variables in the form of cumulative distribution functions.

QRAS, also developed by NASA, assesses risk of failure of a system or a mission based on the quantitative information provided by NESTEM or other similar codes, and user provided fault tree and modes of failure.

This paper will describe briefly, the capabilities of the NESTEM, QRAS and the interface. Also, in this presentation we will describe stepwise process the interface uses using an example.

# NESTEM-QRAS: A Tool for Estimating Probability of Failure

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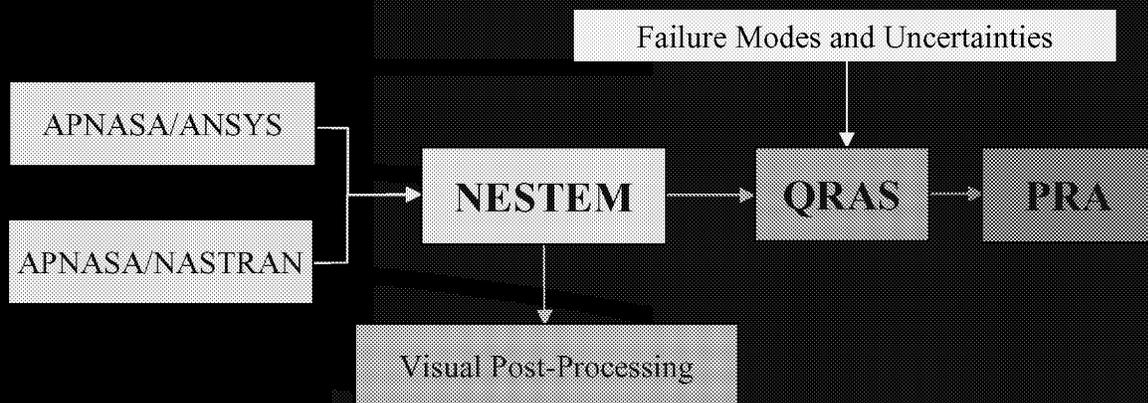
# Outline of Presentation

- Tool Overview
- Tool Components
  - NESTEM
  - QRAS
- Risk Assessment Process
- Example problem
- Benefits of the tool

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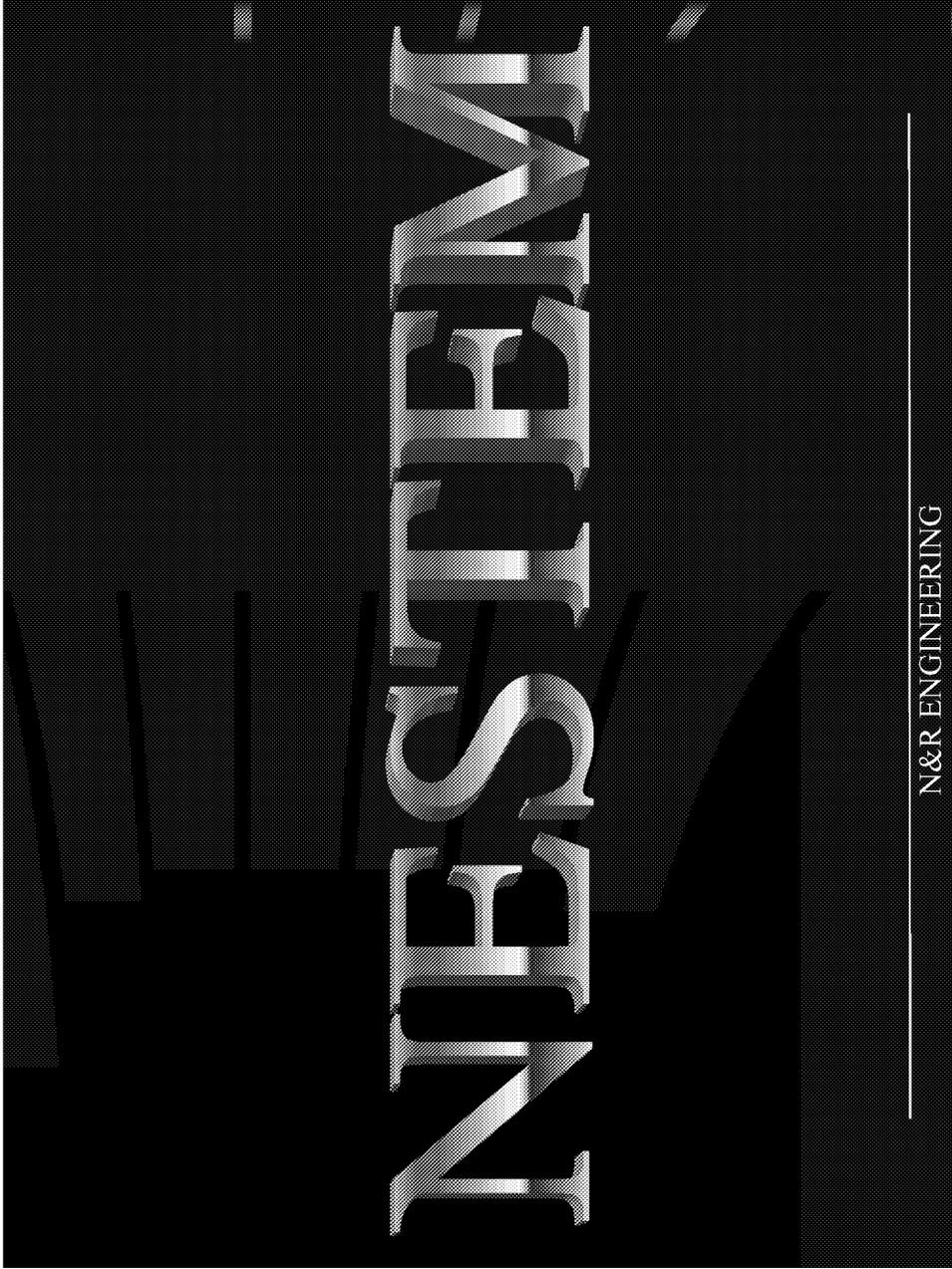
# Tool Overview



- NESTEM interfaces with APNASA/ANSYS or NASTRAN.
- Visual results in ANSYS environment
- QRAS for engine system Probabilistic Risk Assessment (PRA).

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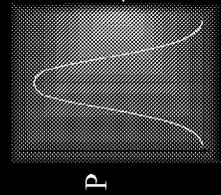
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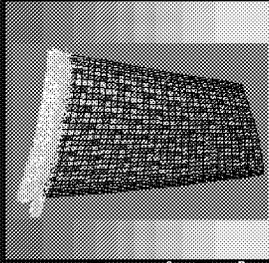
# Probability of Component Failure using NESTEM

Multidisciplinary Probabilistic Heat Transfer/Structural Analysis Code

Probabilistic Loads

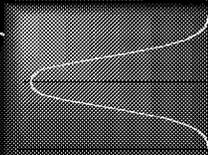


Mechanical



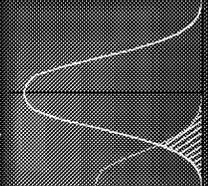
Response (stress)

Probabilistic Materials Behavior



Geometry and Material

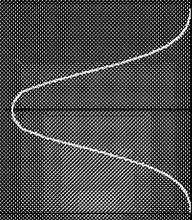
Thermal



Failure

Probability of Occurrence

Resistance (strength)

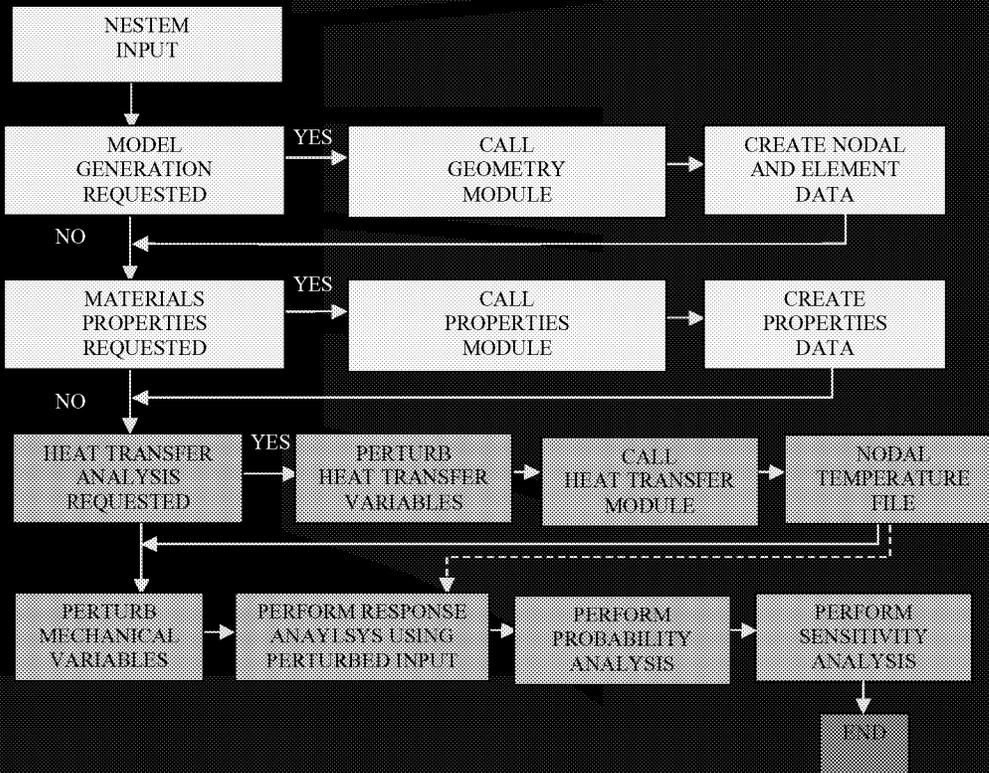


Structural Response

Information for Reliability & Risk Assessment

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# NESTEM FLOW CHART



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# NESTEM Capabilities

- Generates or allows users to import a finite element model from commercial codes such as ANSYS or NASTRAN
- Generates laminate properties from constituent properties in case of composites
- Performs probabilistic heat analysis by perturbing heat transfer variables
- Quantifies influences of uncertainties in material properties and geometry, mechanical and thermal loads on structural responses

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# NESTEM Capabilities

- Generates probability distributions of the response variables based on quantified influences of uncertainties. This feature provides complete ranges of variation in response variables
- This information is very useful for assessing risk of failure, cost or allowable risk and developing maintenance schedule
- Ranks all variables in the order of their influences on response variables. This information is critical for being cost effective

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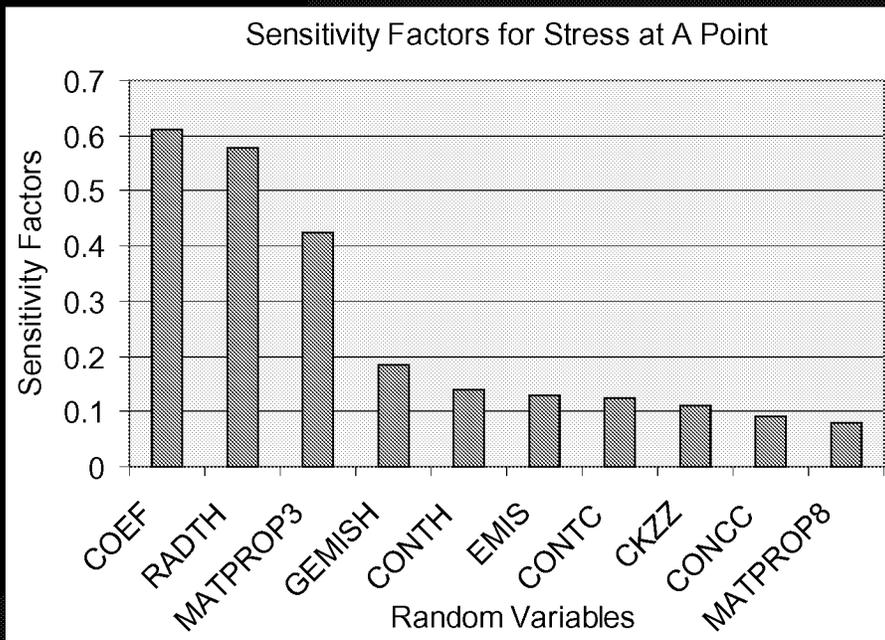
# NESTEM Capabilities

- Estimates fatigue life for random loading
- Post processes results in user's selected environment
- Works on PC and workstation platforms

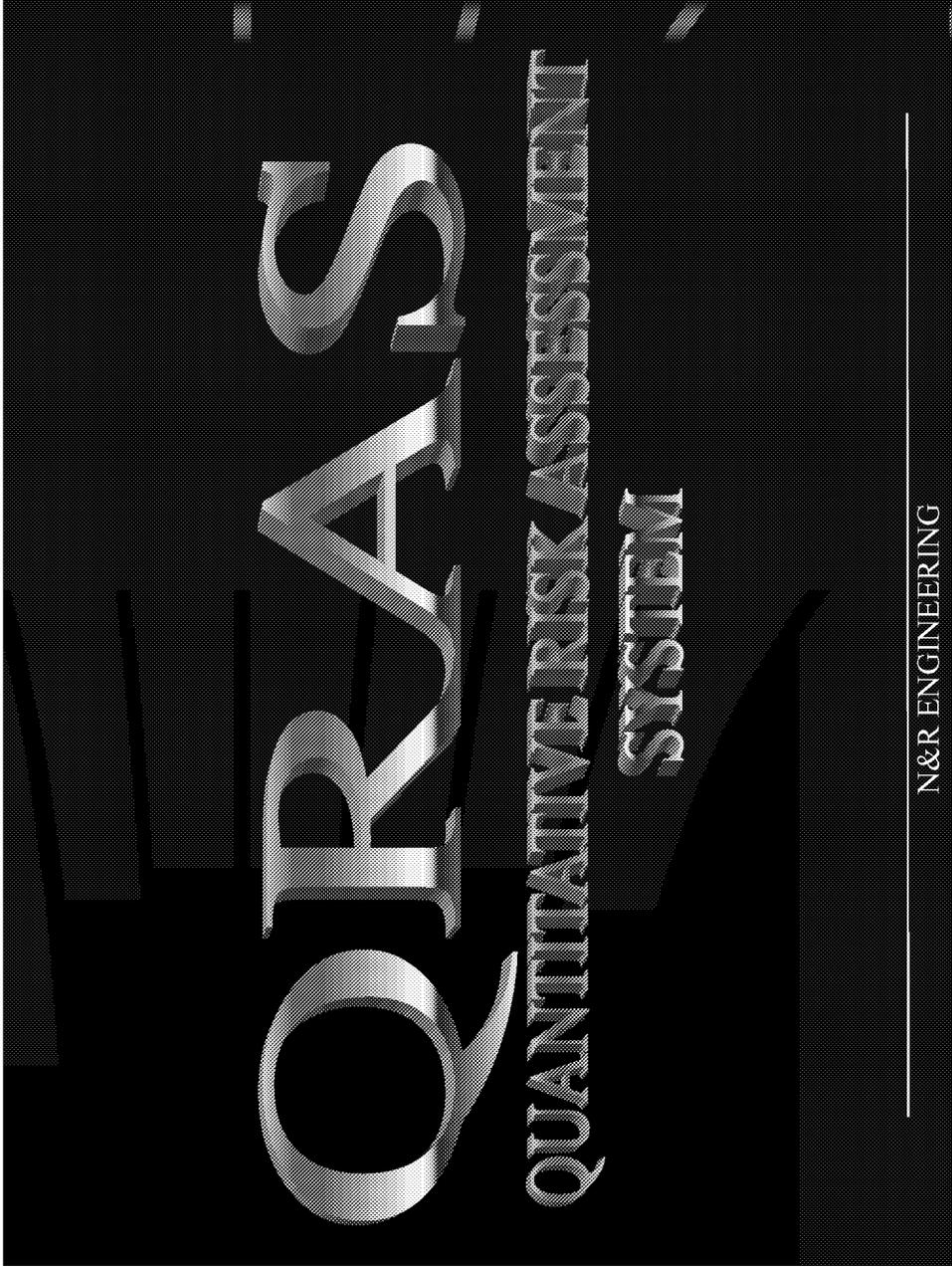
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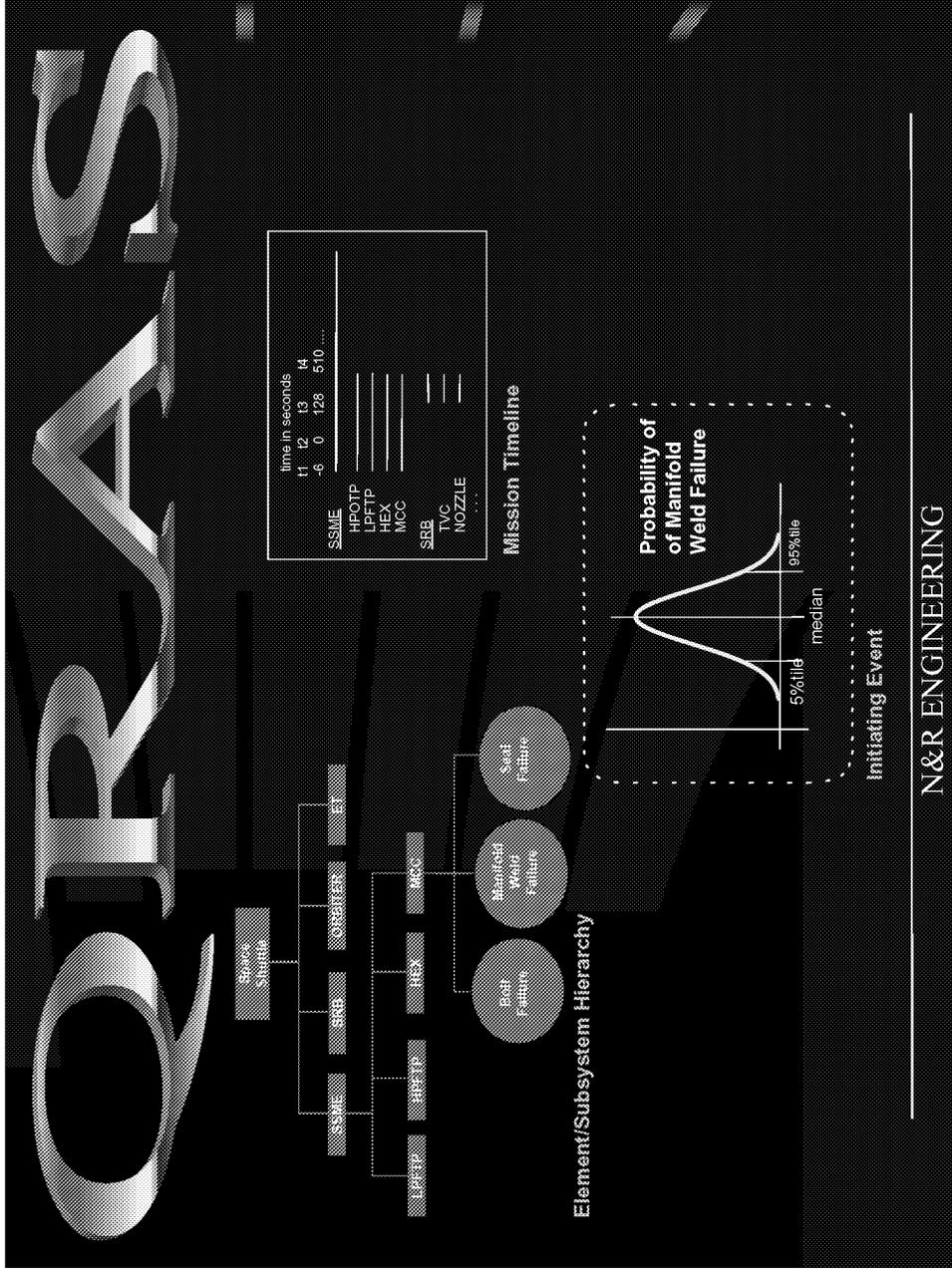
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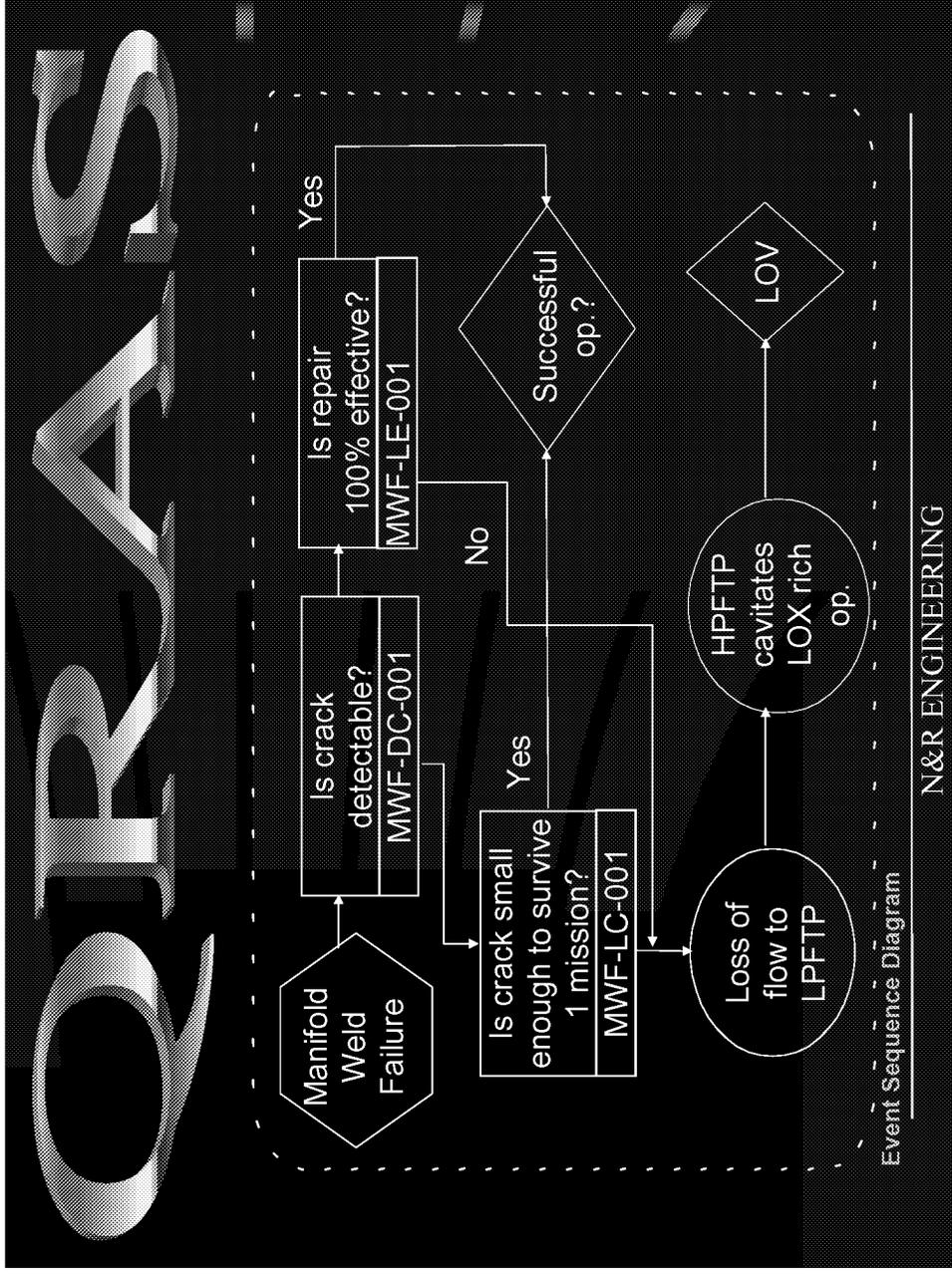
# Plot of Sensitivity Analysis



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Risks by :

1. Space Shuttle
2. Element
3. Subsystem

Risks Ranked :

1. Over entire Shuttle
2. Within Element
3. Within Subsystem, etc.

Probabilistic Risk Assessment

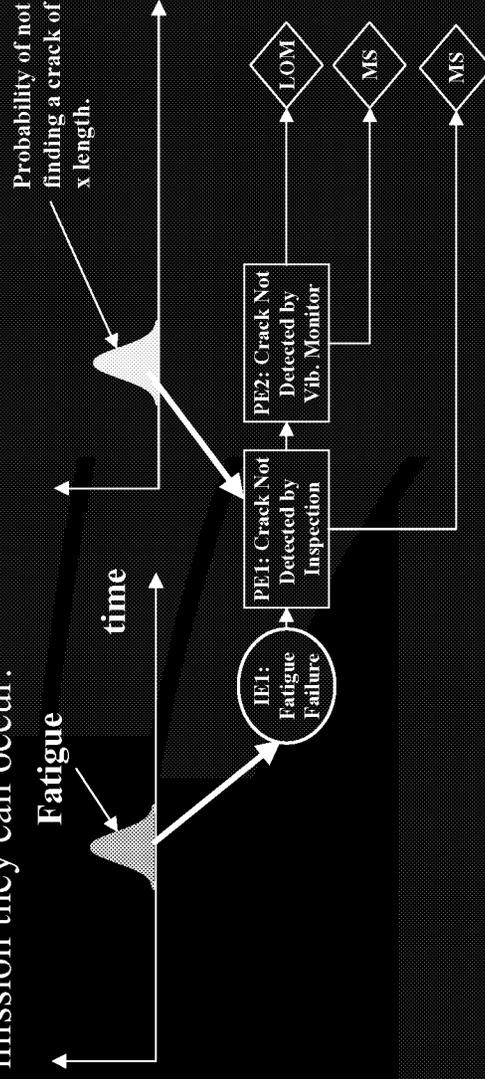
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# Risk of Failure

(Using NESTEM, experience, test data, field data, etc.)

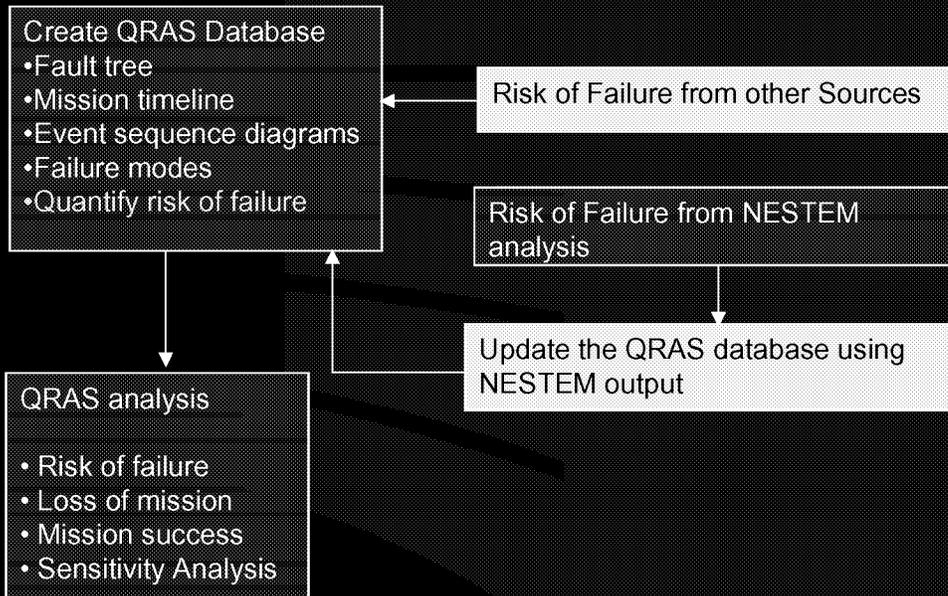
Probabilities are assigned to the failure modes and to the mitigating events. Failure modes are quantified as to when in the mission they can occur.



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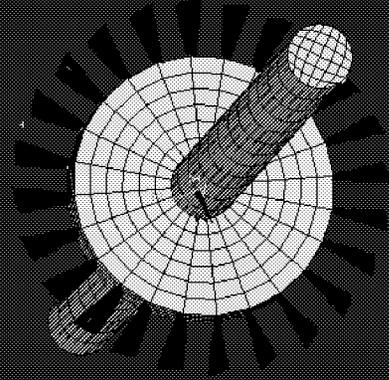


# Risk Assessment Process



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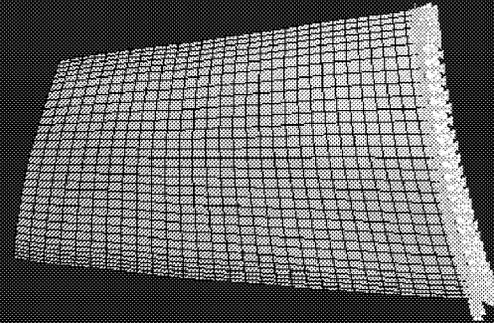
# Example Problem



Shaft-Rotor-Blade Assembly

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# Example Problem



Blade

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# Example Problem

## Example problem Input (Starting Phase):

Component	Risk of failure (C)	Mitigation event (E)	Timeline	Mode of failure
Shaft	0.0	.0925	0-360	Strength
Rotor	0.03905	.0705	0-360	Strength
Blade	0.001438	0.007050	0-360	Strength

(Uniform distribution is assumed)

## Example problem output:

Probability of Loss of Mission from QRAS analysis = 0.02763

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# Benefits of NESTEM-QRAS Tool

This tool provides:

- Risk of failure of individual component
- Risk of failure of a system
- Quantitative ranking of components by degree of risk
- Means to reduce risk of failure
- Cost effective ways to use resources

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# Future Work

- Improve the capability of the tool
- Develop an interface between NESTEM and SAPHIRE

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